

NASA HAT Lab activities

- **M:N**
 - Working group
 - Sims
 - HDV
 - Issues
- **Human as failsafe**
 - Risk based interface with cognitive aiding
- PAAV
 - Auto-cargo m:N
- Hazard Perception and Avoidance
 - ACAS-Xr

M:N Operations



Working Group

- Broad collective of interested stakeholders from government, industry, and academia
- Identify and reduce barriers to m:N operations
 - Technical
 - Regulatory
 - safety assurance
 - community acceptance
 - Identified barriers are considered across a variety of multi-vehicle control contexts (e.g., Urban/Advanced Air Mobility, drone delivery, infrastructure inspection, disaster response and recovery, and high-altitude pseudo-satellite operations)
- Operational approval roadmap
- AUVSI – April, 2022

HITLs

- Roles and Responsibilities
 - Complete (Uber)
- Hand-offs/Switching
 - Data analysis (Joby)
- Communication (Fall, 2022, Spring, 2023)
 - UAM (Joby, Wisk)
 - Small auto drone (Zipline)

HDV Fleet Manager Plays

- Re-Route Tool
 - Pre-Flight
 - Develop initial flight plan
 - Constraints, goals (prioritized), HAT principles or consequences, info/display requirements
 - Modify flight plan in case of PSU rejection
 - Climb/Cruise (single & multi vehicle)
 - Develop amended flight plan in case of vehicle/airspace/vertiport anomaly
 - Must meet constraints of whatever off-nominal event forces amendment
 - Develop amended flight plan in case of non-conformance (either change e.g., speed of aircraft or change route)
 - Approach
 - Develop amended flight plan in case of vertiport resource change
- Handoff Plays (single & multi vehicle)
 - Real-time workload metrics of operators – informs FM of necessary/potential need for handoff relief; also recommends who can accept handoff
- Fleet-wide Plays
 - One event causing change with multiple vehicles vs multiple events causing changes with multiple vehicles
 - Changes at vertiport
 - All land for some airspace emergency/security breach
 - Loss of PSU

Issues for m:N Use-Case

- Comm – datalink, auto-fill pilot aids, PSU's
- Auto DAA – how might this work, collision avoidance or DAA as well...
- Displays- display of multiple alerts/prioritization
- Pilot aids – in such high workload situations, what aids would help
- SA displays – how can we identify, prioritize and display the required info at the required time.
- Lost link – how can we maintain predictability for ATC but still have DAA

Technical Barriers

Type	Barriers
sUAS	<ol style="list-style-type: none"> 1. How do you keep Staff trained on technical systems where taking over is infrequent? 2. Identify what info operator needs 3. Ensure calibrated operator trust 4. Scaling from lower number of vehicles to higher numbers 5. How do you certify autonomous systems?
Large UAS	<ol style="list-style-type: none"> 1. SA for pilot 2. Managing multiple voice channels (w/latency) 3. Contingency management capabilities 4. How to demonstrate pilot's ability to work in m:N framework?
UAM	<ol style="list-style-type: none"> 1. Battery management 2. On demand operators to handle exceptions 3. Crew to vehicle ratio 4. Comms 5. DAA systems (vision, sensor fusion)
HAPS	<ol style="list-style-type: none"> 1. Identify appropriate time horizons relevant to m:N interactions 2. Identifying how SA needs to change in nominal vs contingency situations? What to display? When? To whom to display?
Swarms	<ol style="list-style-type: none"> 1. SA of swarm state due to emergent behavior 2. Supervisory control 3. Impact of environmental and geo. Restrictions 4. Hardware failures

Operational Barriers

Type	Barriers
sUAS	<ol style="list-style-type: none"> 1. What level of automation is needed? 2. How much workload can a single operator handle? How do you staff for spikes in workload?
Large UAS	<ol style="list-style-type: none"> 1. In-flight changes 2. Pilot response time 3. New/increased human error under new paradigm 4. Identify correct level of pilot involvement
UAM	<ol style="list-style-type: none"> 1. Handoff conops 2. Enough funding for infrastructure 3. Integration of ATM/UTM/etc. 4. Corridors
HAPS	<ol style="list-style-type: none"> 1. Standard/Accepted method for demonstrating that an organization's HAPS operations are "safe" and don't degrade safety of NAS 2. Justification of how many vehicles an operator can control
Swarms	<ol style="list-style-type: none"> 1. Define operating environment and procedures 2. Operator roles: across boundaries, when swarm splits/mergers, when failures occur 3. How many operators is enough?

Regulatory Barriers

Type	Barriers
sUAS	<ol style="list-style-type: none">1. How do you show that your operations are safe enough and do not degrade the safety of the national airspace?
Large UAS	<ol style="list-style-type: none">1. Identify pilot role2. Certification with less human involvement3. What data is needed to support regulatory changes?
UAM	<ol style="list-style-type: none">1. Liability2. Certification3. Noise
HAPS	<ol style="list-style-type: none">1. Certification of highly automated systems2. Identifying what policies need to change
Swarms	<ol style="list-style-type: none">1. Certification for non-deterministic behavior2. Defining airspace restrictions

Public Acceptance Barriers

Type	Barriers
sUAS	<ol style="list-style-type: none">1. Is the general public willing to accept sUAS flying over homes, etc.?2. Public acceptance of automation and trust (could be a generational issue)
Large UAS	-
UAM	<ol style="list-style-type: none">1. Generational differences2. Credibility3. Noise4. Emissions
HAPS	<ol style="list-style-type: none">1. How to weigh perceived societal value against third-party risk2. Lack of ability to understand and quantify risk associated with upscaling HAPS operations
Swarms	<ol style="list-style-type: none">1. Explanability2. Reduce fear factor, immediate fear factor

Common Barriers

Type	Barriers	Timeline (near/mid/long term)
Technical	<ol style="list-style-type: none"> Determining and maintaining adequate/appropriate SA, depends on many things: vehicle class, risk posture, LOA, scale, operator role <ol style="list-style-type: none"> Is the level identified by the breakdown of roles and responsibilities? 	
Operational	<ol style="list-style-type: none"> Centralized (or decentralized) management system for task/work/airspace allocation If you have an operator who is managing multiple assets <ol style="list-style-type: none"> How many can they manage? Is it shared? If shared, how to split the responsibilities? Should there be a distinction in operational barriers between RPAS and fully autonomous (e.g., Loon-like) operations? 	
Regulatory	<ol style="list-style-type: none"> Certification: automation, non-determinist system, airframe 	
Public Acceptance	<ol style="list-style-type: none"> Transparency, explainability, trust 	

SWS – Human as a Failsafe

How to address designs that rely on the human to jump in and save the day when automation fails?

Failsafe

- Develop risk-based interface
- Use advanced diagnostics to identify trends prior to alert stage
- Provide this SA and high probability mitigations to humans through cognitive aiding (HAT assistant)

Ways to work together

- Join working group
 - Communicate
- Coordinate research issues
- **Over-guide request to TTT or AAM**
 - Collaborate